1971

Range Version I

U.S. International Biological Program

IBP

DESERT BIOME

US/IBP ANALYSIS OF ECOSYSTEMS

MODELS

RANGE

VERSION I

MODELLING REPORT SERIES NUMBER 5

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VERSION 1

DESERT BIOME
UTAH STATE UNIVERSITY
LOGAN, UTAH 84321
MAY 1971

THE PREPARATION OF THIS MODEL WAS WHOLLY SUPPORTED THROUGH THE US/IBP DESERT BIOME PROGRAM, UNDER GRANT # GB 15886 FROM THE NATIONAL SCIENCE FOUNDATION.

I N T R O D U C T I O N

Reports in this series are intended for internal use by Desert Biome collaborators. They are not to be quoted or referred to in formal publications. These reports have been produced by the Desert Biome Modelling Group, with the assistance of participants in the Desert Biome and other researchers.

The main function of the models, at this stage of their development, is to provide guidance in the research efforts of the Biome. Therefore, it will be noted that most of the information which they contain is fragmentary evidence, best available estimates, arbitrary assumptions or non-Biome supported research. The collection and incorporation of more accurate data will come after these models have been prepared in this form. Validation of the models will also come later.

Any use of the models must recognize the limitations imposed by their development at this early stage of research.

(1) Biological interpretations must be performed with extreme caution. Output, for example, should be viewed in relation to system behavior (stability, general time relationships, relative magnitude of the variables, general responses to parameter modifications, etc.). These properties should be related to the processes incorporated in the model structure. No particular significance should be attached to the specific numbers given as output.

(2) Data included in these models must not be used without explicit approval of the investigators who have supplied them to us. Please contact the Desert Biome Central Office for details.

(3) The material contained in the models does not constitute publication. It is subject to revision. The modeling group requests that this material not be cited without their expressed permission.

As particular models are revised we will be re-issuing them in new versions. The versions will be numbered according to the general scheme:

Version 1. Models which have been developed by the modeling group in isolation from subject area specialists who have provided the question which has been modeled.

Version 2. Models revised to incorporate subject-areas specialist's criticisms.

Version 3. Models revised to incorporate finds of biome-sponsored research.

```
1               RANGE:  PROC OPTIONS(MAIN);
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  THIS IS A MODEL DEALING WITH THE  INTERACTIONS OF RODENTS AND    */
                /*  RABBITS WITH THE PROCESS OF RANGE DETERIORATION. SPECIFICALLY,   */
                /*  IT IS DESIGNED TO EXPLORE THE QUESTION 'ARE RODENTS THE          */
                /*  CAUSE, OR THE RESULT, OF RANGE DETERIORATION?'.                  */
                /*  THE ARGUMENT WHICH WOULD MAKE THEM THE CAUSE CLAIMS THAT THEIR   */
                /*  POPULATIONS ARE RELEASED BY PREDATOR CONTROL. THIS CAN BE        */
                /*  SIMULATED IN THIS MODEL BY A GENERAL DECREASE IN POST-           */
                /*  REPRODUCTIVE DIE-OFF OF RODENT AND RABBIT POPULATIONS.           */
                /*  ACCORDING TO THE ARGUMENT WHICH WOULD MAKE INCREASES IN          */
                /*  RODENT POPULATIONS A SECONDARY EFFECT OF RANGE DETERIORATION,    */
                /*  THE DETERIORATION LEADS, FIRST, TO A GREATER GROWTH OF ANNUAL    */
                /*  AND WEEDY SPECIES, ON WHICH RODENTS THRIVE, AND TO A MEASURE     */
                /*  OF BRUSH INVASION, PROVIDING THE COMBINATION OF COVER AND OF     */
                /*  OPEN SPACE WHICH IS THE BEST HABITAT FOR RABBITS.                */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  NO FACILITY FOR CHANGES IN COVER OF TYPES OTHER THAN             */
                /*  PERENNIAL GRASSES (E.G. BRUSH INVASION) IS INCORPORATED IN       */
                /*  THIS VERSION.                                                */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  THE MODEL VISUALISES A SERIES OF DISCRETE EVENTS DURING EACH     */
                /*  YEAR.                                                        */
                /*  FIRST (IN SPRING) THERE IS A GROWTH OF ANNUALS. THE REPRODUCTION */
                /*  OF RODENTS AND OF RABBITS DEPENDS ON THIS. THE GROWTH IS NOT     */
                /*  USED BY CATTLE.                                              */
                /*  NEXT (DURING THE SUMMER) THE PERENNIAL GRASSES GROW. THIS PROD-  */
                /*  UCTION IS USED BY CATTLE, AND BY THE SUMMER POPULATIONS OF       */
                /*  RODENTS AND RABBITS, WHICH HOWEVER ARE NOT AFFECTED BY ITS       */
                /*  ABUNDANCE. THE COVER OF PERENNIAL GRASSES CHANGES, DEPENDING     */
                /*  ON WHETHER CONSUMPTION EXCEEDS PRODUCTION OR VICE VERSA.         */
                /*  DURING LATE SUMMER THE  POPULATIONS OF RODENTS AND OF RABBITS    */
                /*  DECLINE IN A WAY WHICH DEPENDS ON THE DRYNESS OF THE YEAR,       */
                /*  AND ON THE EXTENT TO WHICH THE HABITAT PROVIDES PROTECTIVE        */
                /*  COVER AGAINST PREDATORS.                                         */
                /*  FIRES MAY ALSO OCCUR DURING THIS PERIOD. THE INTENSITY OF THE    */
                /*  FIRE DEPENDS ON THE AVAILABILITY OF MATERIALS, IN PARTICULAR     */
                /*  ON THE PERCENT COVER OF PERENNIAL GRASS AND OF TREES. THE        */
                /*  COVER OF VEGETATION COMPONENTS IS AFFECTED BY THE FIRE.          */
                /*  FINALLY THE INFILTRATION CAPACITY OF THE SOIL MAY BE ALTERED BY  */
                /*  TRAMPLING BY CATTLE.                                             */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  THE ATTRIBUTES OF PARAMETERS ARE DECLARED.                       */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
```

```
2                       DCL INTPOL ENTRY(FLOAT DEC,(*)FLOAT DEC,(*)FLOAT DEC)
                        RETURNS(FLOAT DEC);
3                       DCL (INFILTRATION_CAPACITY,
                             PERRENNIAL_GRASS_COVER,
                             PRODUCTION_OF_ANNUALS,
                             PRODUCTION_OF_PERENNIAL_GRASS,
                             MAXIMUM_RABBIT_DIE_OFF,
                             MAXIMUM_RODENT_DIE_OFF,
                             PROBABILITY_OF_FIRE_START,
                             INFILTRATION) FLOAT DEC;
4                       DCL  (YEAR,FIRE_INTENSITY) FIXED BIN;
5                       DCL EFFECT_OF_FIRE_ON_COVER(4,3) FLOAT DEC;
6                       DCL  OUTPUT_TYPE FIXED BIN;
7                       DCL  XPRIMER FIXED DEC(12,9);
                    /*                                                      */
                    /************************************************************/
                    /*  THE FOLLOWING ARE ARRAYS WHICH ARE USED IN THE INTERPOLATING    */
                    /*  ROUTINE.                                            */
                    /*                                                      */
                    /************************************************************/
                    /*                                                      */
8                       DCL (COVER_RESPONSE_TO_GRAZING_X,COVER_RESPONSE_TO_GRAZING_Y)
                            (8) FLOAT DEC;
9                       DCL (RABBIT_REPRODUCTION_X,RABBIT_REPRODUCTION_Y) (3)
                            FLOAT DEC;
10                      DCL (INFILTRATION_X,INFILTRATION_Y) (4) FLOAT DEC;
11                      DCL (ANNUAL_PLANT_PRODUCTION_X,ANNUAL_PLANT_PRODUCTION_Y) (4)
                            FLOAT DEC;
12                      DCL (RAIN_PROBABILITY_X,RAIN_PROBABILITY_Y) (4) FLOAT DEC;
13                      DCL (PERENNIAL_GRASS_PRODUCTION_X,PERENNIAL_GRASS_PRODUCTION_Y)
                            (4) FLOAT DEC;
14                      DCL (COVER_SENSITIVITY_X,COVER_SENSITIVITY_Y) (7) FLOAT DEC;
15                      DCL (COVER_FACTOR_X,COVER_FACTOR_Y) (4) FLOAT DEC;
16                      DCL (AVAILABILITY_OF_SUCCULENTS_X,AVAILABILITY_OF_SUCCULENTS_Y)
                            (4) FLOAT DEC;
17                      DCL (DROUGHT_FACTOR_X,DROUGHT_FACTOR_Y) (3) FLOAT DEC;
18                      DCL (RODENT_REPRODUCTION_X,RODENT_REPRODUCTION_Y) (3)
                            FLOAT DEC;
19                      DCL (COMPACTION_X,COMPACTION_Y) (3) FLOAT DEC;
                    /*                                                      */
                    /************************************************************/
                    /*  THE 'GET DATA;' STATEMENT OBTAINS ALL ASSIGNMENT STATEMENTS     */
                    /*  BEFORE THE FIRST SEMI-COLON IN THE DATA DECK.       */
                    /*                                                      */
                    /************************************************************/
                    /*                                                      */
20                      GET DATA;
```

```
                /*                                                              */
                /*****************************************************************/
                /*  THE COORDINATES FOR THE GRAPHS ARE READ IN.                  */
                /*                                                               */
                /*****************************************************************/
                /*                                                               */
21                      IDIM=DIM(COVER_RESPONSE_TO_GRAZING_X,1);
22                         DO I=1 TO IDIM;
23                         GET LIST(COVER_RESPONSE_TO_GRAZING_X(I),
                                    COVER_RESPONSE_TO_GRAZING_Y(I));
24                         END;
25                      IDIM=DIM(RABBIT_REPRODUCTION_X,1);
26                         DO I=1 TO IDIM;
27                         GET LIST(RABBIT_REPRODUCTION_X(I),RABBIT_REPRODUCTION_Y(I));
28                         END;
29                      IDIM=DIM(INFILTRATION_X,1);
30                         DO I=1 TO IDIM;
31                         GET LIST(INFILTRATION_X(I),INFILTRATION_Y(I));
32                         END;
33                      IDIM=DIM(ANNUAL_PLANT_PRODUCTION_X,1);
34                         DO I=1 TO IDIM;
35                         GET LIST(ANNUAL_PLANT_PRODUCTION_X(I),
                                    ANNUAL_PLANT_PRODUCTION_Y(I));
36                         END;
37                      IDIM=DIM(RAIN_PROBABILITY_X,1);
38                         DO I=1 TO IDIM;
39                         GET LIST(RAIN_PROBABILITY_X(I),RAIN_PROBABILITY_Y(I));
40                         END;
41                      IDIM=DIM(PERENNIAL_GRASS_PRODUCTION_X,1);
42                         DO I=1 TO IDIM;
43                         GET LIST(PERENNIAL_GRASS_PRODUCTION_X(I),
                                    PERENNIAL_GRASS_PRODUCTION_Y(I));
44                         END;
45                      IDIM=DIM(COVER_SENSITIVITY_X,1);
46                         DO I=1 TO IDIM;
47                         GET LIST(COVER_SENSITIVITY_X(I),COVER_SENSITIVITY_Y(I));
48                         END;
49                      IDIM=DIM(COVER_FACTOR_X,1);
50                         DO I=1 TO IDIM;
51                         GET LIST(COVER_FACTOR_X(I),COVER_FACTOR_Y(I));
52                         END;
```

```
53                      IDIM=DIM(AVAILABILITY_OF_SUCCULENTS_X,1);
54                         DO I=1 TO IDIM;
55                         GET LIST(AVAILABILITY_OF_SUCCULENTS_X(I),
                                    AVAILABILITY_OF_SUCCULENTS_Y(I));
56                         END;
57                      IDIM=DIM(DROUGHT_FACTOR_X,1);
58                         DO I=1 TO IDIM;
59                         GET LIST(DROUGHT_FACTOR_X(I),DROUGHT_FACTOR_Y(I));
60                         END;
61                      IDIM=DIM(RODENT_REPRODUCTION_X,1);
62                         DO I=1 TO IDIM;
63                         GET LIST(RODENT_REPRODUCTION_X(I),RODENT_REPRODUCTION_Y(I));
64                         END;
65                      IDIM=DIM(COMPACTION_X,1);
66                         DO I=1 TO IDIM;
67                         GET LIST(COMPACTION_X(I),COMPACTION_Y(I));
68                         END;
69                         DO I=1 TO 4;
70                         GET LIST((EFFECT_OF_FIRE_ON_COVER(I,J)DO J=1 TO 3));
71                         END;
```

```
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /* THE NEXT GROUP OF STATEMENTS USES THE PROCEDURE PUT_CURVE IN */
                /* ORDER TO OUTPUT THE SETS OF COORDINATES GIVEN FOR THE        */
                /* INTERPOLATING GRAPHS IN EASILY VISIBLE FORM.                 */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
72                CALL PUT_CURVE
                 ('RESPONSE OF COVER TO PRODUCTION/CONSUMPTION RATIO',
                       COVER_RESPONSE_TO_GRAZING_X,COVER_RESPONSE_TO_GRAZING_Y);
73                CALL PUT_CURVE
                 ('RESPONSE OF RABBIT REPRODUCTION TO GROWTH OF ANNUALS',
                       RABBIT_REPRODUCTION_X,RABBIT_REPRODUCTION_Y);
74                PUT PAGE;
75                CALL PUT_CURVE
                 ('RESPONSE OF SOIL MOISTURE TO INFILTRATION CAPACITY',
                       INFILTRATION_X,INFILTRATION_Y);
76                CALL PUT_CURVE
                 ('RESPONSE OF ANNUALS TO SOIL MOISTURE',
                       ANNUAL_PLANT_PRODUCTION_X,ANNUAL_PLANT_PRODUCTION_Y);
77                PUT PAGE;
78                CALL PUT_CURVE
                 (' CUMULATIVE PROBABILITIES FOR ANNUAL RAIN',
                       RAIN_PROBABILITY_X,RAIN_PROBABILITY_Y);
79                CALL PUT_CURVE
                 (' RESPONSE OF PERENNIAL GRASS TO SOIL MOISTURE',
                       PERENNIAL_GRASS_PRODUCTION_X,PERENNIAL_GRASS_PRODUCTION_Y);
80                PUT PAGE;
81                CALL PUT_CURVE
                 ('RELATIVE SENSITIVITY OF DIFFERENT AMOU TS OF COVER',
                       COVER_SENSITIVITY_X,COVER_SENSITIVITY_Y);
82                CALL PUT_CURVE
                 (' SURVIVAL VALUE OF COVER',
                       COVER_FACTOR_X,COVER_FACTOR_Y);
83                PUT PAGE;
84                CALL PUT_CURVE
                 ('SURVIVAL VALUE F SUCCULENT FOOD',
                       AVAILABILITY_OF_SUCCULENTS_X,AVAILABILITY_OF_SUCCULENTS_Y);
85                CALL PUT_CURVE
                 ('SURVIVAL VALUE OF RAIN',
                       DROUGHT_FACTOR_X,DROUGHT_FACTOR_Y);
86                PUT PAGE;
87                CALL PUT_CURVE
                 ('RESPONSE OF RODENT REPRODUCTION TO GROWTH OF ANNUALS',
                       RODENT_REPRODUCTION_X,RODENT_REPRODUCTION_Y);
88                CALL PUT_CURVE
                 ('RESPONSE OF SOIL INFILTRATION RATE TO STOCKING RATE',
                       COMPACTION_X,COMPACTION_Y);
89                PUT PAGE;
```

```
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  TWO TYPES OF OUTPUT ARE AVAILABLE: FIVE COLUMNS OF MAJOR    */
                /*  VARIABLES (TYPE 1), OR NEARLY ALL VARIABLES IN A LESS LEGIBLE */
                /*  FORM (TYPE 2).                                              */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
90                      IF OUTPUT_TYPE=1 THEN
91                      PUT LIST('RAIN','INFILTRATION CAPACITY','GRASS COVER',
                                'RODENTS','RABBITS');
```

```
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THIS VERSION OF THIS MODEL DOES NOT, BY AND LARGE, DEAL IN  */
                /*  REAL NUMBERS. ALL UNITS ARE PER HECTARE. POPULATIONS OF     */
                /*  ANIMALS ARE GIVEN IN NUMBERS OF INDIVIDUALS. PLANT PRODUCTION */
                /*  IS IN SOME CASES GIVEN IN KILOGRAMS PER HECTARE. COVER OF   */
                /*  PLANTS IS A NUMBER BETWEEN 0 AND 1. CERTAIN OTHER PROPERTIES ARE */
                /*  NOT GIVEN ABSOLUTE VALUES, BUT ARE DESCRIBED BY A RELATIVE  */
                /*  INDEX BETWEEN 0 AND 1.                                      */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE YEAR CYCLE BEGINS.                                      */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
92              YEARS:
                        DO YEAR=1 TO #_OF_YEARS;
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE RAINFALL FOR THE YEAR IS DERIVED BY APPLYING A RANDOM   */
                /*  NUMBER TO A CUMULATIVE PROBABILITY CURVE.                   */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
93              CLIMATE:    R_N=RANDOM;
94                         RAINFALL=INTPOL(R_N,RAIN_PROBABILITY_X,RAIN_PROBABILITY_Y);
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE AMOUNT OF THIS RAINFALL THAT CAN INFILTRATE DEPENDS ON  */
                /*  THE TOTAL FALLING. IT ALSO IS MODIFIED BY THE RELATIVE      */
                /*  INFILTRATION CAPACITY OF THE SOIL, FINALLY GIVING AN INDEX OF */
                /*  SOIL MOISTURE BETWEEN 0 AND 1.                              */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
95                      INFILTRATION=INFILTRATION_CAPACITY*INTPOL(RAINFALL,
                                                                 INFILTRATION_X,
                                                                 INFILTRATION_Y);
```

```
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  THE FUNCTION DIM FINDS THE DIMENSION OF (NUMBER OF COORDINATE    */
                /*  PAIRS IN) THE INTERPOLATION ARRAY INFILT_X (IN THIS CASE).       */
                /*  THIS DIMENSION (KDIM IN THIS CASE) IS THEN USED TO FIND THE      */
                /*  MAXIMUM Y VALUE OF THE GRAPH.                                    */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
96                        KDIM=DIM(INFILTRATION_X,1);
97                        SOIL_MOISTURE_INDEX=INFILTRATION/INFILTRATION_Y(KDIM);
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  THE 'COVER' OF ANNUALS IS REGARDED AS EQUIVALENT TO THE          */
                /*  GROUNDSTOREY SPACE WHICH IS NOT OCCUPIED BY PERENNIAL GRASSES.   */
                /*  THE PRODUCTION IS IN DIRECT PROPORTION TO THIS AMOUNT OF SPACE.  */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
98              ANNUALS:
                          ROOM_FOR_ANNUALS=1-PERENNIAL_GRASS_COVER;
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  ANNUAL PRODUCTION AGAIN IS AN INDEX BETWEEN 0 AND 1. IT          */
                /*  DEPENDS ON THE SOIL MOISTURE INDEX, AS WELL AS ON THE SPACE      */
                /*  AVAILABLE.                                                       */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
99                        PRODUCTION_OF_ANNUALS=ROOM_FOR_ANNUALS*
                                          INTPOL(SOIL_MOISTURE_INDEX,
                                                 ANNUAL_PLANT_PRODUCTION_X,
                                                 ANNUAL_PLANT_PRODUCTION_Y);
```

```
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  RODENT REPRODUCTION IS THE PROPORTIONAL INCREASE IN RODENT   */
                /*  POPULATIONS BETWEEN SPRING AND SUMMER. IT IS DETERMINED BY THE */
                /*  INDEX OF THE PRODUCTION OF ANNUALS, INDEPENDENTLY OF CURRENT */
                /*  RODENT DENSITY. RABBIT REPRODUCTION WORKS IN THE SAME KIND   */
                /*  OF WAY, BUT IS LESS SENSITIVE TO THE CROP OF SPRING ANNUALS. */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
100             RODENTS:
                          RODENT_REPRODUCTION=INTPOL(PRODUCTION_OF_ANNUALS,
                                                     RODENT_REPRODUCTION_X,
                                                     RODENT_REPRODUCTION_Y);
101                       SUMMER_RODENT_POPULATION=WINTER_RODENT_POPULATION*
                                                   RODENT_REPRODUCTION;
102             RABBITS:  RABBIT_REPRODUCTION=INTPOL(PRODUCTION_OF_ANNUALS,
                                                     RABBIT_REPRODUCTION_X,
                                                     RABBIT_REPRODUCTION_Y);
103                       SUMMER_RABBIT_POPULATION=WINTER_RABBIT_POPULATION*
                                                   RABBIT_REPRODUCTION;
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /*  THE PRODUCTION OF PERENNIAL GRASS IS FOUND IN A WAY SIMILAR */
                /*  TO THAT OF ANNUALS, BUT IS EXPRESSED IN KG./HA.             */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
104             GRASS:
                          PRODUCTION_OF_PERENNIAL_GRASS=PERENNIAL_GRASS_COVER*INTPOL
                                                        (SOIL_MOISTURE_INDEX,
                                                         PERENNIAL_GRASS_PRODUCTION_X,
                                                        PERENNIAL_GRASS_PRODUCTION_Y);
```

```
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE AMOUNT OF PERENNIAL GRASS REMOVED BY HERBIVORES IS GIVEN */
                /*  BY (NUMBERS)*(CONSUMPTION RATE PER INDIVIDUAL)*(TIME). CATTLE */
                /*  STOCKING IS PROBABLY YEAR ROUND, AT A CONSTANT LEVEL; FOR   */
                /*  RODENTS AND RABBITS THE SUMMER POPULATION IS USED, AND IT    */
                /*  IS ASSUMED THAT THEY ONLY EAT THE PERENNIAL GRASSES DURING THE */
                /*  SUMMER PERIOD.                                              */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
105             GRAZING:
                          GRASS_USE=(SUMMER_RODENT_POPULATION*RODENT_CONSUMPTION_RATE+
                                     SUMMER_RABBIT_POPULATION*RABBIT_CONSUMPTION_RATE)
                                    *SMALL_MAMMAL_GRASS_USE_PERIOD
                                    +CATTLE_GRASS_USE_PERIOD*CATTLE_STOCKING
                                    *CATTLE_CONSUMPTION_RATE;
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE RATIO OF PRODUCTION TO CONSUMPTION OF PERENNIAL GRASSES IS */
                /*  CALLED THE GRAZING INDEX.                                   */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
106                       IF GRASS_USE=0 THEN
107                       GRAZING_INDEX=0;
108                       ELSE
108                       GRAZING_INDEX=PRODUCTION_OF_PERENNIAL_GRASS/GRASS_USE;
```

```
                /*                                                              */
                /******************************************************************/
                /*                                                              */
                /*  THE POPULATIONS OF RODENTS AND RABBITS ARE REDUCED DURING THE    */
                /*  LATE SUMMER DOWN TO THE POPULATION WHICH WILL BREED NEXT YEAR.   */
                /*  THE GREATEST POSSIBLE REDUCTION IS SET EQUAL TO THE GREATEST     */
                /*  POSSIBLE REPRODUCTION. THE DIE-OFF IS CUSHIONED BY EFFECTS OF    */
                /*  THE ABSENCE OF DROUGHT AND THE AVAILABILITY OF SUCCULENT FOOD,   */
                /*  FOR RODENTS, AND THESE TWO PLUS THE AVAILABILITY OF PROTECTIVE   */
                /*  COVER FOR RABBITS.                                              */
                /*                                                              */
                /******************************************************************/
                /*                                                              */
109             DIE_OFF:
                          ANIMAL_COVER=TREE_COVER+SHRUB_COVER_COEFFICIENT*SHRUB_COVER;
110                       DROUGHT_FACTOR=INTPOL(RAINFALL,DROUGHT_FACTOR_X,
                                                DROUGHT_FACTOR_Y);
111                       SUCCULENT_FACTOR=INTPOL(OPUNTIA_COVER,
                                                  AVAILABILITY_OF_SUCCULENTS_X,
                                                  AVAILABILITY_OF_SUCCULENTS_Y);
112                       COVER_FACTOR=INTPOL(ANIMAL_COVER,COVER_FACTOR_X,
                                              COVER_FACTOR_Y);
113                       JDIM=DIM(RABBIT_REPRODUCTION_X,1);
114                       MAXIMUM_RABBIT_DIE_OFF=RABBIT_REPRODUCTION_Y(JDIM);
115                       RABBIT_DIE_OFF=MAXIMUM_RABBIT_DIE_OFF*DROUGHT_FACTOR*
                                         SUCCULENT_FACTOR*COVER_FACTOR;
116                       JDIM=DIM(RODENT_REPRODUCTION_X,1);
117                       MAXIMUM_RODENT_DIE_OFF=RODENT_REPRODUCTION_Y(JDIM);
118                       RODENT_DIE_OFF=MAXIMUM_RODENT_DIE_OFF*DROUGHT_FACTOR*
                                         SUCCULENT_FACTOR;
119                       WINTER_RABBIT_POPULATION=SUMMER_RABBIT_POPULATION/
                                                   RABBIT_DIE_OFF;
120                       WINTER_RODENT_POPULATION=SUMMER_RODENT_POPULATION/
                                                   RODENT_DIE_OFF;
```

```
                /*                                                              */
                /******************************************************************/
                /*                                                              */
                /*  FIRES START WITH A CERTAIN PROBABILITY TO WHICH A RANDOM    */
                /*  NUMBER IS APPLIED. THE FIRE MAY BE OF THREE INTENSITIES: 1  */
                /*  IS THE LOWEST; THE INTENSITY WILL BE TWO IF THERE IS A      */
                /*  SUFFICIENT COVER OF PERENNIAL GRASS TO CARRY THE FIRE, AND  */
                /*  3 IF THERE IS A SUFFICIENT COVER OF TREES.                  */
                /*                                                              */
                /******************************************************************/
                /*                                                              */
121             FIRE:
                        R_N=RANDOM;
122                       IF R_N<PROBABILITY_OF_FIRE_START THEN
123                          DO;
124                          FIRE_INTENSITY=1;
125                             IF PERENNIAL_GRASS_COVER>FIRE_CARRYING_GRASS_COVER
                THEN
126                             FIRE_INTENSITY=2;
127                             IF TREE_COVER>FIRE_CARRYING_TREE_COVER THEN
128                             FIRE_INTENSITY=3;
129                          PUT LIST('FIRE                              INTENSITY=',
                                FIRE_INTENSITY);
130                          PUT SKIP;
                /*                                                              */
                /******************************************************************/
                /*                                                              */
                /*  THE SENSITIVITY TO CHANGE OF THE COVER OF ALL PHYSIOGNOMIC  */
                /*  TYPES OF VEGETATION DEPENDS ON THE AMOUNT OF COVER. IT IS   */
                /*  LOW AT HIGH COVER VALUES (THE VEGETATION IS 'CLOSED'), HIGH */
                /*  AT INTERMEDIATE LEVELS, AND LOW AT LOW LEVELS (BECAUSE THE  */
                /*  POSSIBILITIES FOR RECOLONIZATION ARE HIGH.)                 */
                /*                                                              */
                /******************************************************************/
                /*                                                              */
131                          TREE_SENS=INTPOL(TREE_COVER,COVER_SENSITIVITY_X,
                                          COVER_SENSITIVITY_Y);
132                          SHRUB_SENS=INTPOL(SHRUB_COVER,COVER_SENSITIVITY_X,
                                          COVER_SENSITIVITY_Y);
133                          OPUNTIA_SENS=INTPOL(OPUNTIA_COVER,COVER_SENSITIVITY_X,
                                          COVER_SENSITIVITY_Y);
134                          P_G_SENS=INTPOL(PERENNIAL_GRASS_COVER,
                                        COVER_SENSITIVITY_X,
                                        COVER_SENSITIVITY_Y);
```

```
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE CHANGE OF THE DIFFERENT TYPES OF COVER IN RESPONSE TO   */
                /*  FIRE DEPENDS ON THE SENSITIVITY OF THE COVER, THE INTENSITY */
                /*  OF THE FIRE, AND THE TYPE OF VEGETATION.                    */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
135                     TREE_COVER=TREE_COVER*(1-TREE_SENS*
                                EFFECT_OF_FIRE_ON_COVER(1,FIRE_INTENSITY));
136                     SHRUB_COVER=SHRUB_COVER*(1-SHRUB_SENS*
                                EFFECT_OF_FIRE_ON_COVER(2,FIRE_INTENSITY));
137                     OPUNTIA_COVER=OPUNTIA_COVER*(1-OPUNTIA_SENS*
                                EFFECT_OF_FIRE_ON_COVER(3,FIRE_INTENSITY));
138                     PERENNIAL_GRASS_COVER=PERENNIAL_GRASS_COVER*
                                        (1-P_G_SENS*
                                EFFECT_OF_FIRE_ON_COVER(4,FIRE_INTENSITY));
139                     END;
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE COVER OF PERENNIAL GRASSES SHIFTS DEPENDING ON WHETHER  */
                /*  THE GRAZING INDEX IS GREATER OR LESS THAN ONE.              */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
140             COVER:      SENSITIVITY_TO_COVER_CHANGE=INTPOL(PERENNIAL_GRASS_COVER,
                                                        COVER_SENSITIVITY_X,
                                                        COVER_SENSITIVITY_Y);
141                     COVER_CHANGE_INDEX=INTPOL(GRAZING_INDEX,
                                        COVER_RESPONSE_TO_GRAZING_X,
                                        COVER_RESPONSE_TO_GRAZING_Y);
142                     PERENNIAL_GRASS_COVER=PERENNIAL_GRASS_COVER*
                                        (1-COVER_CHANGE_INDEX*
                                         SENSITIVITY_TO_COVER_CHANGE);
```

```
                /*                                                              */
                /****************************************************************/
                /*                                                              */
                /*  THE RATE OF COMPACTION OF THE SOIL (ITS LOSS OF INFILTRATION     */
                /*  CAPACITY) DEPENDS ON THE TRAMPLING OF CATTLE. THE MINIMUM       */
                /*  INFILTRATION CAPACITY IS .2.                                    */
                /*                                                              */
                /****************************************************************/
                /*                                                              */
143             TRAMPLING:
                          SOIL_COMPACTION=INTPOL(CATTLE_STOCKING,COMPACTION_X,
                                                 COMPACTION_Y);
144                       INFILTRATION_CAPACITY=INFILTRATION_CAPACITY*
                                               (1-SOIL_COMPACTION*
                                                (INFILTRATION_CAPACITY-.2));
```

```
145                         IF OUTPUT_TYPE=1 THEN
146                         PUT LIST(RAINFALL,INFILTRATION_CAPACITY,
                                    PERENNIAL_GRASS_COVER,WINTER_RODENT_POPULATION,
                                    WINTER_RABBIT_POPULATION);
147                         IF OUTPUT_TYPE=2 THEN
148                            DO;
149                            PUT SKIP DATA(YEAR);
150                            PUT SKIP DATA(RAINFALL,INFILTRATION,
                                          SOIL_MOISTURE_INDEX,
                                          PRODUCTION_OF_ANNUALS,
                                          RODENT_REPRODUCTION,RABBIT_REPRODUCTION,
                                          SUMMER_RODENT_POPULATION,
                                          SUMMER_RABBIT_POPULATION,
                                          PRODUCTION_OF_PERENNIAL_GRASS,
                                          PERENNIAL_GRASS_COVER,GRASS_USE,
                                          GRAZING_INDEX,DROUGHT_FACTOR,
                                          SUCCULENT_FACTOR,COVER_FACTOR,
                                          RABBIT_DIE_OFF,RODENT_DIE_OFF,
                                          WINTER_RABBIT_POPULATION,
                                          WINTER_RODENT_POPULATION,
                                          R_N,TREE_COVER,SHRUB_COVER,
                                          OPUNTIA_COVER,SOIL_COMPACTION,
                                          INFILTRATION_CAPACITY);
151                               END;
152                      END YEARS;
```

```
                /*                                                              */
                /*****************************************************************/
                /*                                                              */
                /*  THE PROCEDURE INTPOL INTERPOLATES LINEARLY BETWEEN THE TWO  */
                /*  NEAREST POINTS ON A GIVEN GRAPH. IF AN X COORDINATE IS GIVEN */
                /*  OUTSIDE THE RANGE OF THE XS DEFINED BY THE DATA, THE Y VALUE */
                /*  WILL BE RETURNED AS THAT CORRESPONDING TO THE HIGHEST OR     */
                /*  LOWEST X VALUE.                                             */
                /*                                                              */
                /*****************************************************************/
                /*                                                              */
153             INTPOL:    PROC(X,XVAL,YVAL)RETURNS(FLOAT DEC);
154                        DCL I FIXED BIN INTERNAL, X FLOAT DEC;
155                        DCL XVAL(*), YVAL(*);
156                        NDIM=DIM(XVAL,1);
157                           IF X<=XVAL(1)THEN
158                           RETURN(YVAL(1));
159                           IF X>=XVAL(NDIM)THEN
160                           RETURN(YVAL(NDIM));
161                           DO I=1 TO NDIM;
162                              IF XVAL(I)>X THEN
163                                 DO;
164                                 AM=(YVAL(I)-YVAL(I-1))/(XVAL(I)-XVAL(I-1));
165                                 C=YVAL(I)-AM*XVAL(I);
166                                 RETURN(AM*X+C);
167                                 END;
168                           END;
169                        END INTPOL;
```

```
                /*                                                              */
                /******************************************************************/
                /*                                                              */
                /* THE PROCEDURE PUT_CURVE TAKES THE SETS OF COORDINATE PAIRS    */
                /* GIVEN TO THE INTERPOLATING ROUTINE AND PRODUCES A GRAPH OF THEM, */
                /* SO THAT THE DATA USED CAN BE MORE READILY EXAMINED.          */
                /*                                                              */
                /******************************************************************/
                /*                                                              */
170             PUT_CURVE: PROC(H,XVAL,YVAL);
171             DCL XVAL(*), YVAL(*), H CHAR(*) , GRAPH(20,40) CHAR(1);
172             DCL ISTORE(*) CTL, JSTORE(*) CTL;
173             NDIM=DIM(XVAL,1);
174             ALLOCATE ISTORE(NDIM), JSTORE(NDIM);
175             XMIN=XVAL(1);
176             XMAX=XVAL(NDIM);
177             YMAX=YVAL(1);
178             YMIN=YVAL(1);
179             DO II=2 TO NDIM;
180             YMIN=MIN(YMIN,YVAL(II));
181             YMAX=MAX(YMAX,YVAL(II));
182             END;
183             XDIV=(XMAX-XMIN)*0.025;
184             YDIV=(YMAX-YMIN)*0.05;
185             GRAPH(*,*)=' ';
186             NPTS=1;
187             DO K = 1 TO NDIM;
188             J=CEIL ((XVAL(K)-XMIN)/XDIV-0.5);
189             IF J > 40 THEN J=40;
191             IF J < 1 THEN J=1;
193             I=CEIL ((YMAX-YVAL(K))/YDIV-0.5);
194             IF I > 20 THEN I=20;
196             IF I < 1 THEN I=1;
198             ISTORE(K)=I;
199             JSTORE(K)=J;
200             GRAPH(I,J)='*';
201             END;
202             DO N = 2 TO NDIM;
203             DO J = JSTORE(N-1)+1 TO JSTORE(N)-1;
204             GRAD=(ISTORE(N)-ISTORE(N-1))/(JSTORE(N)-JSTORE(N-1));
205             C = ISTORE(N)-(GRAD*JSTORE(N));
206             I = CEIL (GRAD*J+C);
207             GRAPH(I,J)='+';
208             END;
209             END;
210             PUT SKIP(2);
211             DO M = 1 TO 20;
212             IF M=1 THEN
213             PUT SKIP EDIT (YMAX,'+',GRAPH(1,*))
                (COL(20),E(11,4),COL(34),A,COL(35),40 A);
214             ELSE IF M = 20 THEN
215             PUT SKIP EDIT (YMIN,'+',GRAPH(20,*))
                (COL(20),E(11,4),COL(34),A,COL(35),40 A);
216             ELSE PUT SKIP EDIT ('|',GRAPH(M,*))
```

```
                (COL(34),A,COL(35),40 A);
217             END;
218             PUT SKIP EDIT ('+________________________________________+')
                (COL(35),A);
219             PUT SKIP EDIT (XMIN,XMAX) (COL(35),E(11,4),COL(64),E(11,4));
220             PUT SKIP(2) EDIT (H) (COL(35),A);
221             END PUT_CURVE;
```

```
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /* THE FORM OF RANDOM-NUMBER GENERATOR USED IN BOTH PL/C AND PL1    */
                /* IS THE PROCEDURE CALL X=RANDOM;. THE PROCEDURE RANDOM ITSELF     */
                /* CALLS THE BASIC SYSTEM PROCEDURE RANDSET. DIFFERENT VERSIONS OF  */
                /* RANDOM ARE USED DEPENDING ON WHETHER THE SOURCE PROGRAMME IS     */
                /* IN PL/C OR PL1.                                                  */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
                /* THIS IS THE PL1 VERSION OF THE RANDOM NUMBER INTERFACE           */
                /* PROCEDURE.                                                   */
                /*                                                              */
                /********************************************************************/
                /*                                                              */
222                RANDOM: PROC RETURNS (FLOAT);
223                DCL ISEED FIXED BIN (31);
224                DCL IPRIME FIXED BIN (31);
225                DCL RAND ENTRY RETURNS (FLOAT);
226                DCL RANDSET ENTRY (FIXED BIN (31), FIXED BIN (31));
227                DCL FIRST_PASS BIT (1) STATIC INIT ('1'B);
228                IF FIRST_PASS THEN DO;
230                      FIRST_PASS='0'B;
231                      ISEED=268513721;
232                      IPRIME=578692357;
233                      CALL RANDSET(ISEED,IPRIME);
234                RANDOM_NUMBER=RAND;
235                RETURN (RANDOM_NUMBER);
236                END RANDOM;
238                     END RANGE;
```

ATTRIBUTE AND CROSS-REFERENCE TABLE

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
	AM	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 164,165,166
	ANIMAL_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 109,112
11	ANNUAL_PLANT_PRODUCTION_X	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 33,35,76,99
11	ANNUAL_PLANT_PRODUCTION_Y	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 35,76,99
98	ANNUALS	STATEMENT LABEL CONSTANT
16	AVAILABILITY_OF_SUCCULENTS_X	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 53,55,84,111
16	AVAILABILITY_OF_SUCCULENTS_Y	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 55,84,111
	C	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 165,166,205,206
	CATTLE_CONSUMPTION_RATE	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105
	CATTLE_GRASS_USE_PERIOD	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105
	CATTLE_STOCKING	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105,143
	CEIL	GENERIC,BUILT-IN FUNCTION 188,193,206
93	CLIMATE	STATEMENT LABEL CONSTANT
19	COMPACTION_X	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 65,67,88,143
19	COMPACTION_Y	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 67,88,143
140	COVER	STATEMENT LABEL CONSTANT
	COVER_CHANGE_INDEX	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 141,142
	COVER_FACTOR	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE)

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
		112,115,150
15	COVER_FACTOR_X	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 49,51,82,112
15	COVER_FACTOR_Y	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 51,82,112
8	COVER_RESPONSE_TO_GRAZING_X	(8)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 21,23,72,141
8	COVER_RESPONSE_TO_GRAZING_Y	(8)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 23,72,141
14	COVER_SENSITIVITY_X	(7)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 45,47,81,131,132,133,134,140
14	COVER_SENSITIVITY_Y	(7)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 47,81,131,132,133,134,140
109	DIE_OFF	STATEMENT LABEL CONSTANT
	DIM	GENERIC,BUILT-IN FUNCTION 21,25,29,33,37,41,45,49,53,57,61,65,96,113,116,156,173
	DROUGHT_FACTOR	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 110,115,118,150
17	DROUGHT_FACTOR_X	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 57,59,85,110
17	DROUGHT_FACTOR_Y	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 59,85,110
5	EFFECT_OF_FIRE_ON_COVER	(4,3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 70,135,136,137,138
121	FIRE	STATEMENT LABEL CONSTANT
	FIRE_CARRYING_GRASS_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 125
	FIRE_CARRYING_TREE_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 127
4 *********	FIRE_INTENSITY	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 124,126,128,129,135,136,137,138
227	FIRST_PASS	STATIC,UNALIGNED,INITIAL,STRING(1),BIT 228,230
	GRAD	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE)

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
		204,205,206
171	GRAPH	(20,40)AUTOMATIC,UNALIGNED,STRING(1),CHARACTER 185,200,207,213,215,216
104	GRASS	STATEMENT LABEL CONSTANT
	GRASS_USE	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105,106,108,150
105	GRAZING	STATEMENT LABEL CONSTANT
	GRAZING_INDEX	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 107,108,141,150
171	H	PARAMETER,UNALIGNED,STRING(*),CHARACTER 170,220
154 *********	I	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 161,162,164,164,164,164,165,165
*********	I	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 22,23,23,26,27,27,30,31,31,34,35,35,38,39,39,42,43,43,46,47,47,50,51 51,54,55,55,58,59,59,62,63,63,66,67,67,69,70,193,194,195,196,197,198 200,206,207
*********	IDIM	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 21,22,25,26,29,30,33,34,37,38,41,42,45,46,49,50,53,54,57,58,61,62,65 66
*********	II	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 179,180,181
3	INFILTRATION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 95,97,150
3	INFILTRATION_CAPACITY	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 95,144,144,144,146,150
10	INFILTRATION_X	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 29,31,75,95,96
10	INFILTRATION_Y	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 31,75,95,97
153	INTPOL	ENTRY,DECIMAL,FLOAT(SINGLE) 94,95,99,100,102,104,110,111,112,131,132,133,134,140,141,143
224	IPRIME	AUTOMATIC,ALIGNED,BINARY,FIXED(31,0) 232,233
223	ISEED	AUTOMATIC,ALIGNED,BINARY,FIXED(31,0)

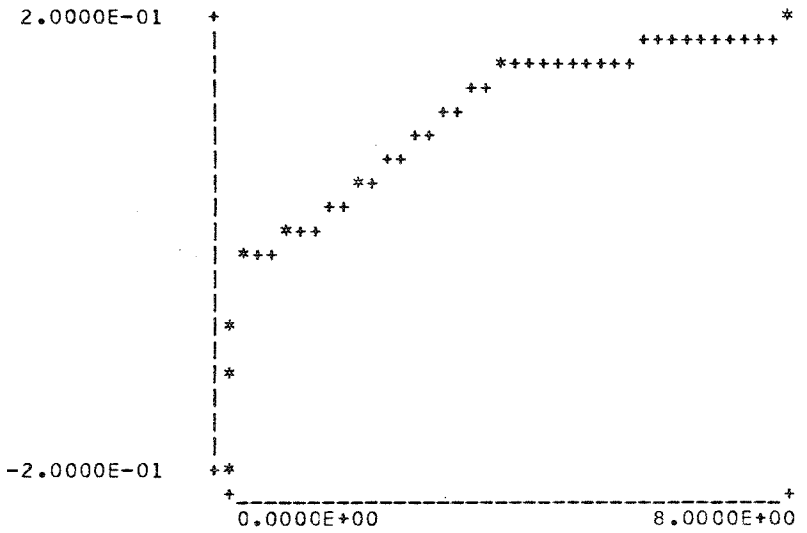
DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
		231,233
172	********* ISTORE	(*)CONTROLLED,ALIGNED,BINARY,FIXED(15,0) 174,198,204,204,205
	#_OF_YEARS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 92
	********* J	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 70,70,188,189,190,191,192,199,200,203,206,207
	********* JDIM	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 113,114,116,117
172	********* JSTORE	(*)CONTROLLED,ALIGNED,BINARY,FIXED(15,0) 174,199,203,203,204,204,205
	********* K	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 187,188,193,198,199
	********* KDIM	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 96,97
	********* M	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 211,212,214,216
	MAX	GENERIC,BUILT-IN FUNCTION 181
3	MAXIMUM_RABBIT_DIE_OFF	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 114,115
3	MAXIMUM_RODENT_DIE_OFF	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 117,118
	MIN	GENERIC,BUILT-IN FUNCTION 180
	********* N	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 202,203,203,204,204,204,204,205,205
	********* NDIM	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 156,159,160,161,173,174,174,176,179,187,202
	********* NPTS	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 186
	OPUNTIA_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 111,133,137,137,150
	OPUNTIA_SENS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 133,137

DCL NO.		IDENTIFIER	ATTRIBUTES AND REFERENCES
6	*********	OUTPUT_TYPE	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 90,145,147
		P_G_SENS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 134,138
		PERENNIAL_GRASS_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 98,104,125,134,138,138,140,142,142,146,150
13		PERENNIAL_GRASS_PRODUCTION_X	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 41,43,79,104
13		PERENNIAL_GRASS_PRODUCTION_Y	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 43,79,104
3		PERRENNIAL_GRASS_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE)
3		PROBABILITY_OF_FIRE_START	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 122
3		PRODUCTION_OF_ANNUALS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 99,100,102,150
3		PRODUCTION_OF_PERENNIAL_GRASS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 104,108,150
170		PUT_CURVE	ENTRY,DECIMAL,FLOAT(SINGLE) 72,73,75,76,78,79,81,82,84,85,87,88
		R_N	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 93,94,121,122,150
		RABBIT_CONSUMPTION_RATE	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105
		RABBIT_DIE_OFF	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 115,119,150
		RABBIT_REPRODUCTION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 102,103,150
9		RABBIT_REPRODUCTION_X	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 25,27,73,102,113
9		RABBIT_REPRODUCTION_Y	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 27,73,102,114
102		RABBITS	STATEMENT LABEL CONSTANT
12		RAIN_PROBABILITY_X	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 37,39,78,94

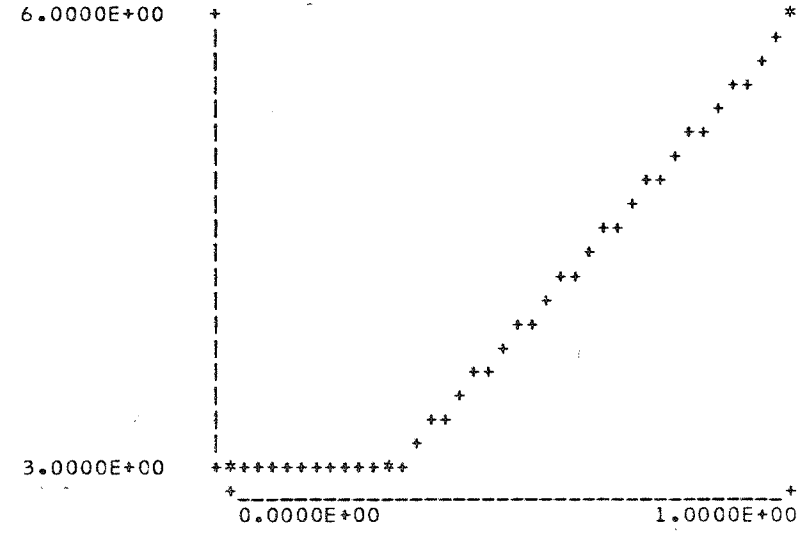
DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
12	RAIN_PROBABILITY_Y	(4)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 39,78,94
	RAINFALL	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 94,95,110,146,150
225	RAND	EXTERNAL,ENTRY,DECIMAL,FLOAT(SINGLE) 234
222	RANDOM	ENTRY,DECIMAL,FLOAT(SINGLE) 93,121
	RANDOM_NUMBER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 234,235
226	RANDSET	EXTERNAL,ENTRY,DECIMAL,FLOAT(SINGLE) 233
1	RANGE	ENTRY,DECIMAL,FLOAT(SINGLE)
	RODENT_CONSUMPTION_RATE	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105
	RODENT_DIE_OFF	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 118,120,150
	RODENT_REPRODUCTION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 100,101,150
18	RODENT_REPRODUCTION_X	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 61,63,87,100,116
18	RODENT_REPRODUCTION_Y	(3)AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 63,87,100,117
100	RODENTS	STATEMENT LABEL CONSTANT
	ROOM_FOR_ANNUALS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 98,99
	SENSITIVITY_TO_COVER_CHANGE	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 140,142
	SHRUB_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 109,132,136,136,150
	SHRUB_COVER_COEFFICIENT	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 109
	SHRUB_SENS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 132,136

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
	SMALL_MAMMAL_GRASS_USE_PERIOD	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 105
	SOIL_COMPACTION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 143,144,150
	SOIL_MOISTURE_INDEX	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 97,99,104,150
	SUCCULENT_FACTOR	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 111,115,118,150
	SUMMER_RABBIT_POPULATION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 103,105,119,150
	SUMMER_RODENT_POPULATION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 101,105,120,150
	SYSIN	FILE,EXTERNAL 20,23,27,31,35,39,43,47,51,55,59,63,67,70
	SYSPRINT	FILE,EXTERNAL 74,77,80,83,86,89,91,129,130,146,149,150,210,213,215,216,218,219,220
143	TRAMPLING	STATEMENT LABEL CONSTANT
	TREE_COVER	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 109,127,131,135,135,150
	TREE_SENS	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 131,135
	WINTER_RABBIT_POPULATION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 103,119,146,150
	WINTER_RODENT_POPULATION	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 101,120,146,150
154	X	PARAMETER,ALIGNED,DECIMAL,FLOAT(SINGLE) 153,157,159,162,166
	XDIV	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 183,188
	XMAX	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 176,183,219
	XMIN	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 175,183,188,219
	XPRIMER	AUTOMATIC,ALIGNED,DECIMAL,FIXED(12,9)

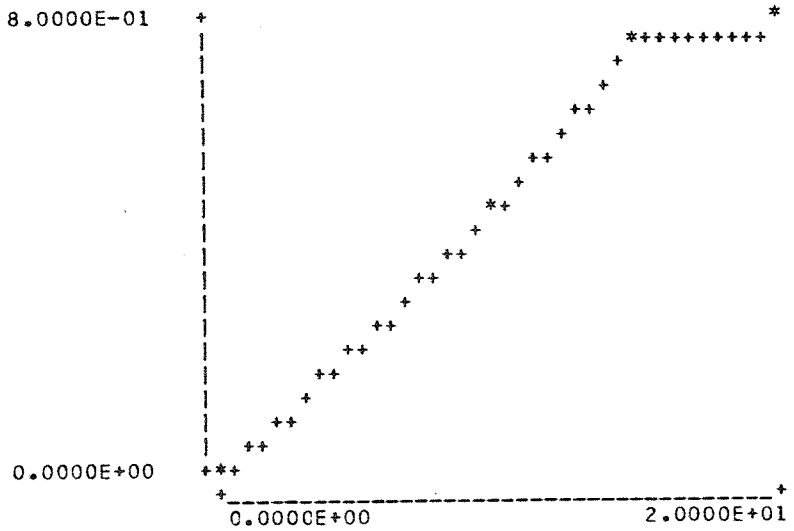
DCL NO.		IDENTIFIER	ATTRIBUTES AND REFERENCES
171		XVAL	(*)PARAMETER,ALIGNED,DECIMAL,FLOAT(SINGLE) 170,173,175,176,188
155		XVAL	(*)PARAMETER,ALIGNED,DECIMAL,FLOAT(SINGLE) 153,156,157,159,162,164,164,165
		YDIV	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 184,193
4	*********	YEAR	AUTOMATIC,ALIGNED,BINARY,FIXED(15,0) 92,149
92		YEARS	STATEMENT LABEL CONSTANT
		YMAX	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 177,181,181,184,193,213
		YMIN	AUTOMATIC,ALIGNED,DECIMAL,FLOAT(SINGLE) 178,180,180,184,215
171		YVAL	(*)PARAMETER,ALIGNED,DECIMAL,FLOAT(SINGLE) 170,177,178,180,181,193
155		YVAL	(*)PARAMETER,ALIGNED,DECIMAL,FLOAT(SINGLE) 153,158,160,164,164,165



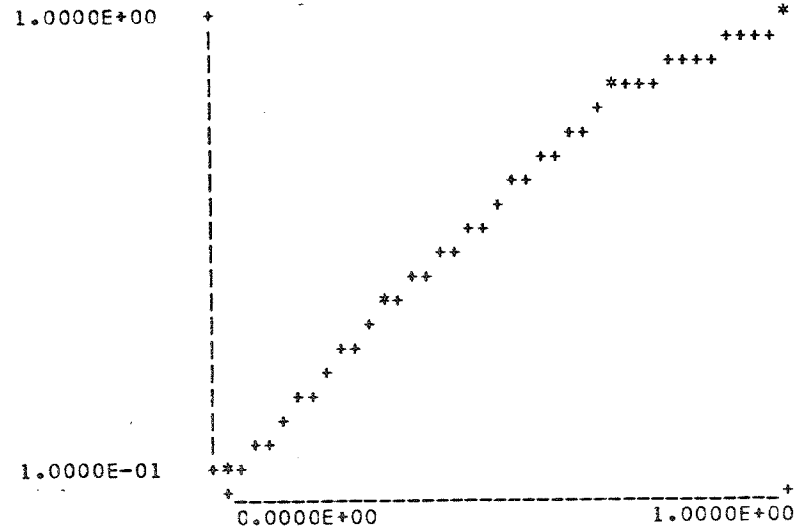
RESPONSE OF COVER TO PRODUCTION/CONSUMPTION RATIO



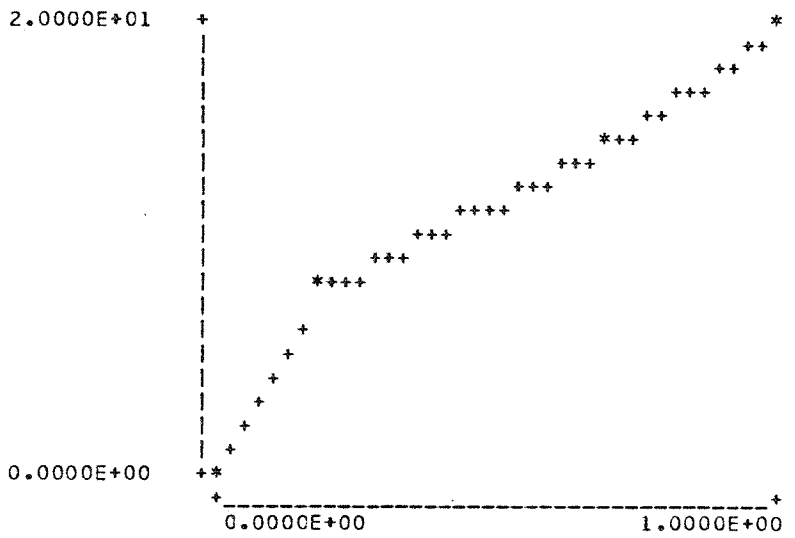
RESPONSE OF RABBIT REPRODUCTION TO GROWTH OF ANNUALS



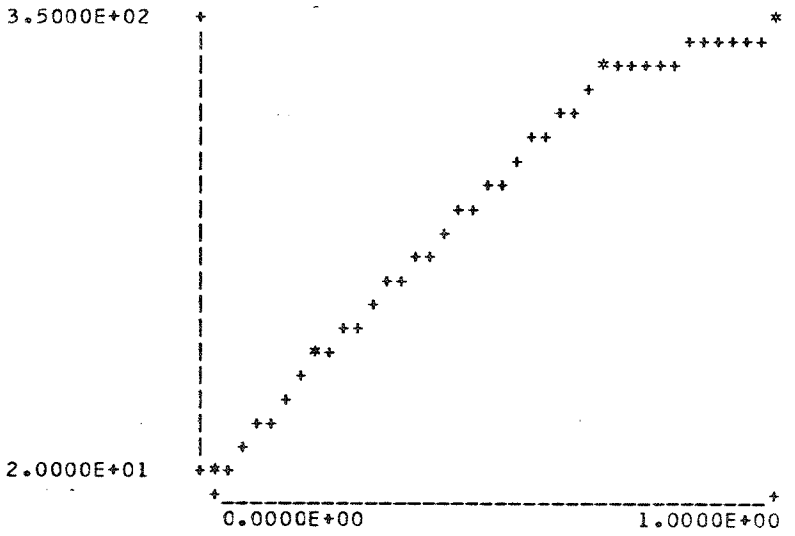
RESPONSE OF SOIL MOISTURE TC INFILTRATION CAPACITY



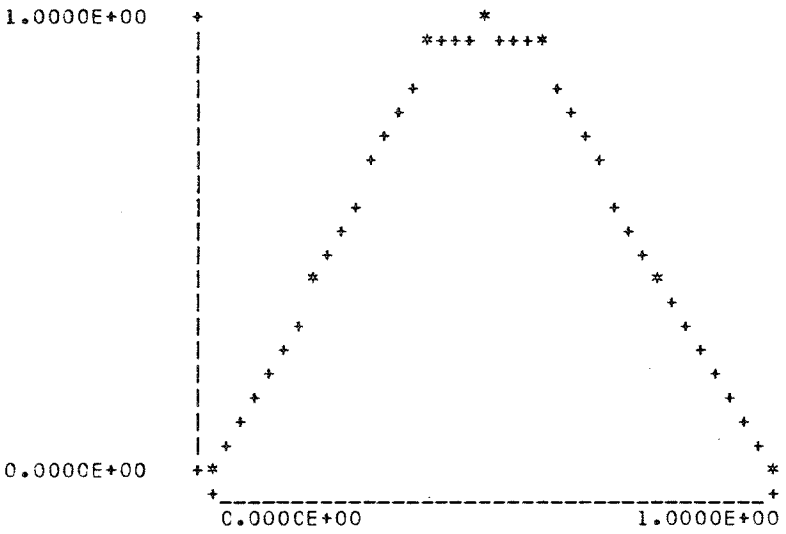
RESPONSE OF ANNUALS TC SCIL MOISTURE



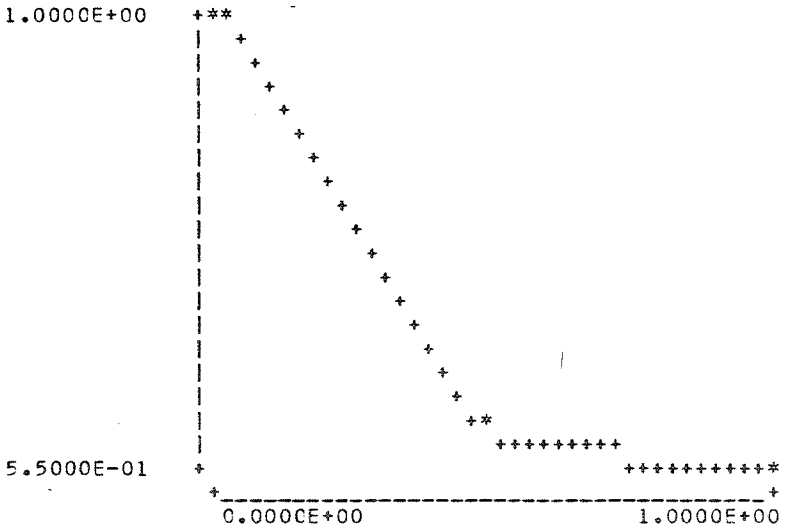
CUMULATIVE PROBABILITIES FOR ANNUAL RAIN



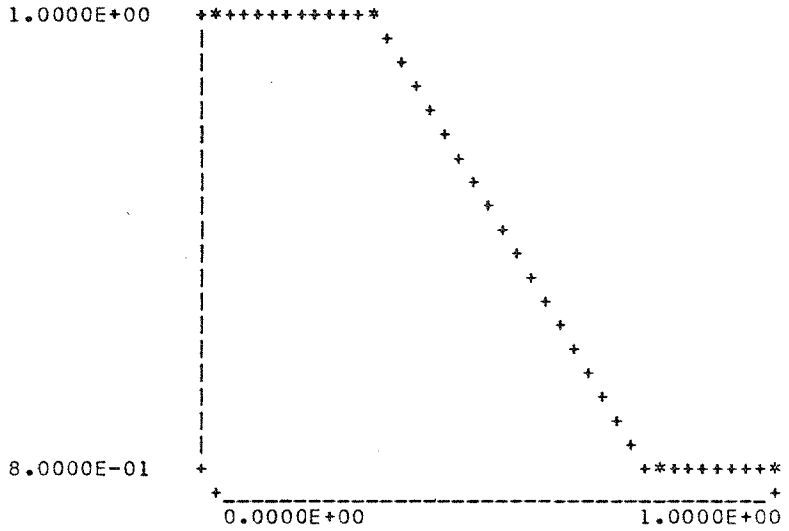
RESPONSE OF PERENNIAL GRASS TO SOIL MOISTURE

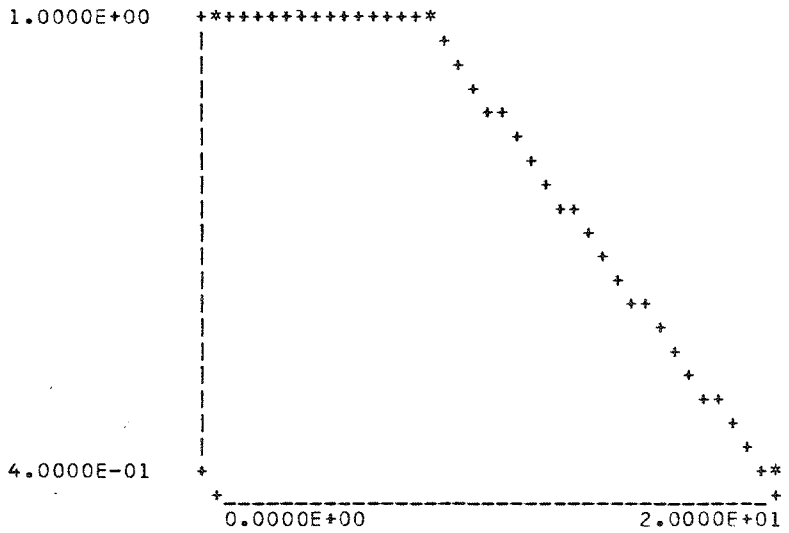


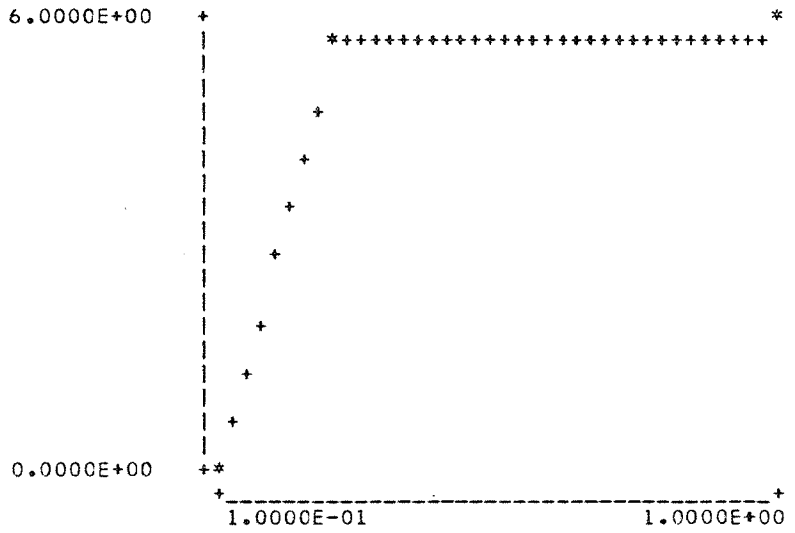
RELATIVE SENSITIVITY CF DIFFERENT AMOU TS CF COVER



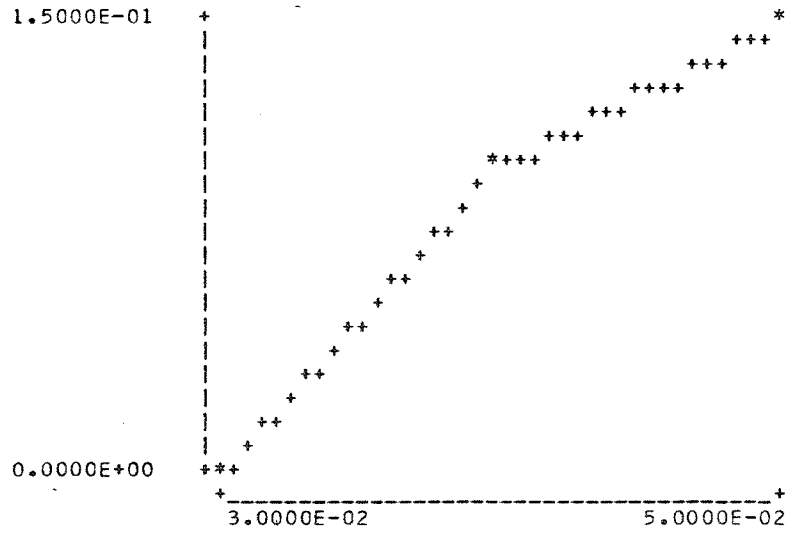
SURVIVAL VALUE OF CCVER


1.0000E+00
8.0000E-01
0.0000E+00
1.0000E+00
SURVIVAL VALUE F SUCCULENT FCOD


1.0000E+00
4.0000E-01
0.0000E+00
2.0000E+01
SURVIVAL VALUE CF RAIN



RESPONSE OF RODENT REPRODUCTION TO GROWTH OF ANNUALS



RESPONSE OF SOIL INFILTRATION RATE TC STOCKING RATE

RAIN	INFILTRATION CAPACITY	GRASS COVER	RODENTS	RABBITS
1.88649E+01	6.82500E-01	7.08402E-01	1.34504E+01	1.28283E+00
2.00000E+01	6.66034E-01	7.18059E-01	1.97542E+01	1.87914E+00
2.00000E+01	6.50514E-01	7.29788E-01	2.62512E+01	2.75266E+00
2.00000E+01	6.35861E-01	7.43744E-01	3.09211E+01	4.03222E+00
2.00000E+01	6.22004E-01	7.60592E-01	3.13803E+01	5.90658E+00
2.00000E+01	6.08879E-01	7.78535E-01	2.61954E+01	8.65222E+00
2.00000E+01	5.96431E-01	7.97272E-01	1.71064E+01	1.26741E+01
2.00000E+01	5.84609E-01	8.17535E-01	8.07297E+00	1.85657E+01
2.00000E+01	5.73367E-01	8.40018E-01	2.30491E+00	2.71958E+01
2.00000E+01	5.62663E-01	8.66068E-01	2.04048E-01	3.98377E+01
2.00000E+01	5.52460E-01	8.93623E-01	0.00000E+00	5.83561E+01
2.00000E+01	5.42724E-01	9.19843E-01	0.00000E+00	8.54827E+01
2.00000E+01	5.33424E-01	9.42801E-01	0.00000E+00	1.25218E+02
2.00000E+01	5.24531E-01	9.61005E-01	0.00000E+00	1.83426E+02
2.00000E+01	5.16020E-01	9.74367E-01	0.00000E+00	2.68690E+02
2.00000E+01	5.07866E-01	9.83609E-01	0.00000E+00	3.93590E+02
2.00000E+01	5.00048E-01	9.89727E-01	0.00000E+00	5.76549E+02
2.00000E+01	4.92546E-01	9.93651E-01	0.00000E+00	8.44555E+02
2.00000E+01	4.85342E-01	9.96114E-01	0.00000E+00	1.23714E+03
2.00000E+01	4.78417E-01	9.97637E-01	0.00000E+00	1.81222E+03
2.00000E+01	4.71757E-01	9.98569E-01	0.00000E+00	2.65462E+03
2.00000E+01	4.65347E-01	9.99136E-01	0.00000E+00	3.88861E+03
2.00000E+01	4.59173E-01	9.99479E-01	0.00000E+00	5.69622E+03
2.00000E+01	4.53223E-01	9.99686E-01	0.00000E+00	8.34408E+03
2.00000E+01	4.47485E-01	9.99811E-01	0.00000E+00	1.22227E+04
2.00000E+01	4.41947E-01	9.99886E-01	0.00000E+00	1.79045E+04
2.00000E+01	4.36601E-01	9.99931E-01	0.00000E+00	2.62273E+04
2.00000E+01	4.31436E-01	9.99957E-01	0.00000E+00	3.84189E+04
2.00000E+01	4.26443E-01	9.99973E-01	0.00000E+00	5.62778E+04
2.00000E+01	4.21615E-01	9.99983E-01	0.00000E+00	8.24383E+04
2.00000E+01	4.16943E-01	9.99989E-01	0.00000E+00	1.20759E+05
2.00000E+01	4.12420E-01	9.99992E-01	0.00000E+00	1.76893E+05
2.00000E+01	4.08040E-01	9.99994E-01	0.00000E+00	2.59122E+05
2.00000E+01	4.03796E-01	9.99996E-01	0.00000E+00	3.79573E+05
2.00000E+01	3.99681E-01	9.99997E-01	0.00000E+00	5.56016E+05
2.00000E+01	3.95691E-01	9.99998E-01	0.00000E+00	8.14478E+05
2.00000E+01	3.91819E-01	9.99998E-01	0.00000E+00	1.19308E+06
2.00000E+01	3.88061E-01	9.99998E-01	0.00000E+00	1.74768E+06
2.00000E+01	3.84412E-01	9.99998E-01	0.00000E+00	2.56068E+06
2.00000E+01	3.80867E-01	9.99998E-01	0.00000E+00	3.75012E+06
2.00000E+01	3.77423E-01	9.99998E-01	0.00000E+00	5.49335E+06
2.00000E+01	3.74075E-01	9.99998E-01	0.00000E+00	8.04692E+06
2.00000E+01	3.70819E-01	9.99998E-01	0.00000E+00	1.17874E+07
2.00000E+01	3.67652E-01	9.99998E-01	0.00000E+00	1.72668E+07
2.00000E+01	3.64570E-01	9.99998E-01	0.00000E+00	2.52932E+07
2.00000E+01	3.61570E-01	9.99998E-01	0.00000E+00	3.70507E+07
2.00000E+01	3.58649E-01	9.99998E-01	0.00000E+00	5.42735E+07
2.00000E+01	3.55804E-01	9.99998E-01	0.00000E+00	7.95023E+07
2.00000E+01	3.53032E-01	9.99998E-01	0.00000E+00	1.16458E+08
2.00000E+01	3.50331E-01	9.99998E-01	0.00000E+00	1.70593E+08